

REINFORCED CONCRETE CODE

**CITY OF COLUMBUS
OHIO**

**DEPARTMENT OF
BUILDINGS**

1913

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Reinforced Concrete Code

AN ORDINANCE No. 27098

To define and describe the term and meaning of reinforced concrete construction and to regulate the manner of its use in building operations.

Be it Ordained by the Council of the City of Columbus, State of Ohio:

Section 1. Definition. By the term Reinforced Concrete in these regulations is meant an approved structural combination of concrete and steel, so arranged that the steel resists all the tensile stresses and may aid the concrete in resisting shear and compression. No system of reinforced concrete design shall be used which is not capable of design and investigation according to the best engineering practice, and the principles laid down in this code.

Sec. 2. Requirements for Permit. Before a permit to erect any reinforced concrete structure is granted, complete plans and specifications showing all details of construction, the size and position of all reinforcing members and the composition of the concrete shall be submitted to the Department of Buildings. The Department of Buildings reserves the right to demand that the owner, architect or engineer submit certified copies of all computations or stress sheets for examination upon application for a building permit.

Permission to erect any reinforced concrete

structure does not in any way approve the construction until after tests have been made of the actual construction to the satisfaction of the Department of Buildings.

Sec. 3. Unit Stresses. The following unit stresses shall not be exceeded:

Medium steel, 16,000 lbs. per sq. in.

High carbon steel, 18,000 lbs. per sq. in.

Steel to resist diagonal tension, 12,000 lbs. per sq. in.

Concrete, extreme fiber in compression, 700 lbs. per sq. in.

Bond stresses for plain round bars, 70 lbs. per sq. in.

Bond stresses for twisted bars or deformed bars, 100 lbs. per sq. in.

Concrete in shear, 50 lbs. per sq. in.

Sec. 4. Assumptions. The following assumptions shall be made as a basis for the calculation of girders, beams and slabs:

(a) The stress strain curve of concrete in compression is a straight line.

(b) The modulus of elasticity of concrete remains constant within the limits of unit working stresses specified in this ordinance.

(c) The adhesion between concrete and steel is sufficient to make the two materials act together.

(d) Concrete has no value in tension.

(e) The ratio of the modulus of elasticity of steel to the modulus of elasticity of concrete is 15.

Sec. 5. Slabs, Beams and Girders. Slabs, beams and girders with uniform distribution of load shall be calculated as follows: When simply supported the moment equals $WL/8$; when continuous over one support the moments shall

be considered as $WL/10$ at center and $WL/8$ over intermediate support; when continuous over two or more supports with equal or approximately equal spans, the moments shall be considered as $WL/12$ at center and over supports of intermediate spans, and $WL/10$ at center of end span and over second support; where "W"=total load and "L"=span in feet.

In continuous slabs, beams and girders, with uniform distribution of load, continuity reinforcing shall extend over and beyond supports at least one-fourth ($1/4$) of the adjoining span.

Concentrated loads shall be computed according to accepted theory, and in the case of continuous spans proper provisions shall be made for continuity.

For slabs, beams and girders the span shall be taken as the distance from center to center of supports, but need not exceed the clear span plus the depth of slab, beam or girder.

Sec. 6. Tee-Beams. Where beams are made monolithic with the floor slab, with the slab reinforcing at right angles to the beam, the slab may be considered as acting in flexure with the beam, provided the width of slab so considered be governed by the shearing resistance between the slab and beam, but be limited on either side of the beam to $1/6$ of the span of the beam between supports and also limited on either side of the beam to five (5) times the thickness of the slab. In case the reinforcing is not at right angles to the beam, the portion of the slab so considered shall be limited on either side of the beam to three (3) times the thickness of the slab. In no case shall the total width of flange so taken exceed the distance center to center of beams.

No part of the slab shall be considered as a

portion of the beam unless the slab and beam are cast at the same time.

Where reinforced concrete girders support reinforced concrete beams, the portion of the floor slab acting as flange to the girder must be reinforced with rods near the top, at right angles to the girder, to enable it to transmit local loads directly to the girder and not through the beams.

In tee-beams construction the bottom of the web over continuous supports shall be provided with haunches, or be reinforced with sufficient steel in compression, to reduce the stress on the concrete to within ten per cent of that allowed at the center of the span. This steel shall project at least twenty-four inches on each side of supports and the unit compressive stress in the steel shall not exceed fifteen (15) times the unit compressive stress in the concrete at the same distance from the neutral axis.

Sec. 7. Square and Rectangular Slabs. For square slabs reinforced in both directions the moments for each set of reinforcing in the center half of the slab shall be taken not less than $WL^2/16$ where the slab under consideration is not continuous; $WL^2/20$ where the slab under consideration is continuous over one support, and $WL^2/24$ at center and over supports where the slab is continuous over both supports; where "W"=the load per square foot and "L"=side of square in feet. The steel in the remaining quarters may be proportioned by using one-half of the amount used in the middle half.

For rectangular slabs, with equal spacing of reinforcing in each direction, the transverse reinforcing shall be proportioned to carry the

amount of load given by the following formula:

$$w = \frac{Wa^4}{a^4 + b^4}$$

Where "w"=load per square foot carried by the transverse reinforcing.

"W"=total load per square foot of slab.

"a"=length of slab and

"b"=breadth of slab.

The moments in the central half of the slab for the transverse reinforcement shall be not less than $wa^2/8$ where the slab is not continuous, $wa^2/10$ where the slab is continuous over one support, and $wa^2/12$ at center and over supports where the slab is continuous over both supports. The steel in the remaining quarters may be proportioned by using one-half ($1/2$) the amount used in the middle half. Where the length of a rectangular slab exceeds one and one-half ($1\frac{1}{2}$) times the breadth, the load shall be assumed to all be carried by the transverse reinforcement.

The amount of load carried to the side beams for square and rectangular slabs shall be taken according to the above assumptions and moments, as derived by the assumption of uniform distribution of load, shall be increased twenty-five (25) per cent.

Sec. 8. Minimum Thickness of Slabs. Reinforced concrete slabs shall not be less than four (4) inches thick for floors, and three and one-half ($3\frac{1}{2}$) inches for roofs in beams and girder construction; except in spans of six feet or under, in which case the above thicknesses may be decreased one-half ($1/2$) inch, provided the unit stresses as herein given are not ex-

ceeded. Slabs shall not be less than two (2) inches thick, with reinforcing at right angles to the beam, for floors using beams spaced close together and separated by hollow tile or other centering or fillers satisfactory to the Inspector of Buildings.

Sec. 9. Reinforced Terra Cotta Hollow Tile.

(a) By reinforced terra cotta tile is meant a system of hollow burned clay tile in combination with reinforced concrete, in which combination the hollow tile may be used to resist compressive and shearing stresses, subject to the following provisions:

The provisions relating to reinforced concrete construction shall hold as far as applicable to this system.

All tile to be hard burned terra cotta tile of uniform quality, deeply scored, free from shrinkage cracks, with true beds, and having an ultimate compressive strength of 4000 lbs. per square inch of the net area of surface tested.

The following unit stresses and values shall not be exceeded. Compression, extreme fiber stress on tile 500 pounds per square inch. Shearing stress on tile 200 pounds per square inch. Adhesion between tile and 1:2; 4 concrete to 1:3 mortar, 40 pounds per square inch.

Ratio of modulus of elasticity of steel to that of tile with cement mortar joints, 10.

(b) Workmanship. The hollow tile shall be thoroughly drenched with water at the time the concrete is poured. The lines of tile shall be true and the joints between tiles shall be staggered.

Sec. 10. Girderless Floor.

By girderless floors is meant a type of reinforced concrete construction in which the columns are pro-

vided with flaring heads and the loads are carried directly to the columns by the slab and not through beams and girders.

The bending moment at the center of the slab shall not be less than $WL/30$ where "W"=total load on panel and "L"=length in feet of the side of a square panel and of the side of an equivalent square in rectangular panels. This length shall be taken center to center of columns. The steel to resist this moment shall be divided into four bands, two in cross and two in diagonal direction over the column head.

Each band of steel shall be approximately $7/16 L$ in width and the total amount of steel in any one band shall not exceed .30 of 1 per cent for high carbon and .36 of 1 per cent for medium steel. In determining the percentage of steel, the width of concrete band so considered shall not exceed the width of band of steel plus twice the thickness of the slab.

All splices shall be made at the column heads and the amount of lap of each bar shall be approximately one-fourth L ($1/4L$). At least 50 per cent of all the bars shall be spliced over each column. In this construction provision shall be made to take care of the circumferential stresses. Proper provisions shall be made for resisting the shear at the capital and for holding the steel in the proper position over the column head.

The diameter of the column head shall never be less than $.25L$ and its profile shall not fall inside of a line drawn from its periphery to the edge of the column and making an angle of 45 degrees with the vertical. The spiral reinforcing of the column shall extend into the

capital approximately to the under side of the slab.

The minimum thickness of the slab shall be seven (7) inches for floors and six and one-half ($6\frac{1}{2}$) inches for roofs.

In end panels or wall panels, in which wall columns of reinforced concrete with flaring heads are omitted an allowance of ten (10) per cent shall be made for increased moments. Wall columns shall be designed to carry one-half the panel load and such other loads as may come upon it, and if necessary the columns shall be designed for eccentric stresses. The wall beams shall be designed for one-third the panel load plus any other loads which may come upon them.

Sec. 11. Web Stresses. Shear on concrete shall not exceed one hundred and twenty (120) pounds per square inch, but where said shear exceeds fifty (50) pounds per square inch, web reinforcement of approved design shall be used. The reinforcement shall be designed to take all web stresses in excess of fifty (50) pounds per square inch, without exceeding the unit stresses hereinbefore given, and must be so spaced as to intersect any 45 degree line of rupture from the neutral axis to the center of the steel. Where unattached stirrups are used, they shall pass under the main reinforcing bars. Attached stirrups shall have connections of sufficient strength to develop the elastic limit of the steel without slipping along or shearing from the main bars. All web reinforcing shall be provided with sufficient anchorage above the neutral axis to develop the safe strength of the member without exceeding the bond stresses hereinbefore given. In computing the intensity of the vertical shear only the area of the web between the center of grav-

ity of the steel and the center of compression of the concrete shall be considered as effective.

Sec. 12. Protection Against Fire and Corrosion. All reinforcing steel shall be protected by concrete of the following minimum thickness: Two (2) inches in columns, one and one-half ($1\frac{1}{2}$) inches for beams and girders, and three-fourths ($\frac{3}{4}$) inches in slabs.

Sec. 13. Reinforced Concrete Columns. Reinforced concrete columns shall not exceed in length fifteen (15) times the least diameter of the column, including the reinforcement, and where such ratio is more than twelve (12) times, the stresses shall be reduced in accordance with the best engineering practice. In computing the strength of columns only the area within the limits of the ties, bands, hooping or spirals shall be considered as effective area. The concrete which must in all cases be provided outside of the ties, bands, hooping or spirals as provided in Section 12, shall be considered only as protection against fire and corrosion. No reinforced concrete column shall be used whose least side or diameter, including the protection against fire and corrosion, is less than twelve (12) inches.

Wall columns and other columns subject to eccentric loads of and indeterminate amount shall have the stresses, as hereinbefore given, reduced by twenty (20) per cent. Eccentric loads of determinate amount shall be computed according to accepted theory, but in no case shall the sum of the stresses due to direct and eccentric loads exceed the maximum stresses hereinafter given for each type of column.

Sec. 14. Square Core Columns. In the square core type of columns, where four rods are used, and the minimum area of each rod

is not less than .4418 of a square inch, and the total area of the rods is not less than one-half ($\frac{1}{2}$) and not more than four (4) per cent of the required area of the column, and the maximum tie spacing does not exceed twelve (12) inches, and in no case more than one-half the distance between two of the vertical rods, and the minimum area of the ties is at least .0625 of a square inch, the following values shall not be exceeded:

7000 pounds per square inch on the vertical steel.

500 pounds per square inch on the concrete.

In the square core type of column, where eight rods are used and the minimum area of each rod is not less than .4418 of a square inch, and the total area of the vertical rods is not less than one-half ($\frac{1}{2}$) of one per cent and not more than five (5) per cent of the required area of the column, and the maximum tie spacing does not exceed twelve (12) inches and in no case more than seven (7) times the diameter of the vertical rods, and the minimum area of the ties is at least .0625 of a square inch, and two sets of ties are used, one in the form of a square inscribed within the outer tie, and the ends of the ties secured in such a manner as will fully develop the elastic limit of the ties; the following values shall not be exceeded:

9000 pounds per square inch on the vertical steel.

600 pounds per square inch on the concrete.

Sec. 15. Round Core Columns. For round core columns vertically reinforced and hooped with circular bands or spirals, the vertical rods shall not be less than four (4) in number, nor the area of the cross section of each rod less

than .4418 of a square inch, nor the maximum spacing of the verticals more than twelve and one-half ($12\frac{1}{2}$) inches measured on the circumference of the spiral, the percentage of spiral hooping shall not be less than one-half of one per cent and not more than one and one-half ($1\frac{1}{2}$) per cent of the area within the hooping, the spacing of the spirals, if such are used, shall not exceed one-seventh ($1/7$) of the diameter of the core and in no case more than three (3) inches. Provided, however, that in cases where properly welded bars are used and there are enough vertical rods of the proper area to give the same restraint as a grill, the spacing of the bands shall not exceed, for the values hereinafter given, seven (7) times the diameter of one such vertical rods.

The following values shall not be exceeded for either of the foregoing conditions:

10,000 pounds per square inch on the vertical steel.

700 pounds per square inch on the concrete.

10,000 pounds per square inch on 2.4 times the volume of the spirals considered as imaginary verticals, provided that the spirals are continuous, machine made, provided with accurate spacers and secured at every intersection.

Provided, however, that if wire hooping is used not less than five-sixteenth ($5/16$) of an inch in diameter (of 80,000 pounds ultimate strength and 50,000 pounds elastic limit) an allowance of twelve thousand pounds per square inch may be used for hooping, provided that whenever such value is allowed, said spirals shall be continuous, machine made, and provided with accurate spacers and secured at every intersection.

Sec. 16. Column Splices. All vertical reinforcing in columns shall be spliced in such manner as will transmit the stresses for which it is designed. Sharp bends in the steel shall be avoided. The splicing of verticals having an area of less than one and one-fourth ($1\frac{1}{4}$) square inches may be done by lapping, the lapped bars to be wired securely to each other. Verticals having an area in excess of one and one-fourth square inches shall be spliced by putting the bars squarely one over the other, and tying the same together by some mechanical means that will not utilize the adhesive strength of the concrete. All splices shall occur only at floors or some other means of lateral support.

Sec. 17. Tension in Columns. In tall narrow buildings special provisions shall be made for tension in columns.

Sec. 18. Additional Stories. Where additional stories are to be added to work over two years old, the strength of the concrete in the existing columns may be taken fifteen (15) per cent higher than the values herein specified.

Sec. 19. Footings. Footings for walls and columns may be constructed of reinforced concrete, providing the working stresses, as given in this code, for concrete and steel are not exceeded, and the steel is protected by at least three (3) inches of concrete.

The vertical rods in reinforced concrete columns shall be anchored to the footings by anchor bars or other means satisfactory to the Inspector of Buildings.

Sec. 20. Reinforced Concrete Curtain Walls. Exterior and interior walls of reinforced con-

crete shall be not less than eight (8) inches thick and reinforced with not less than three-tenths (3/10) of one per cent of steel in each direction, vertically and horizontally. Rods shall be spaced not more than twelve (12) inches on centers and shall be wired to each other at each intersection.

Sec. 21. Cement. Only Portland cement shall be used which conforms to the standard specifications of the Society for testing materials. All cement shall be tested in lots of not more than one carload, and the Department of Buildings may at any time demand that certified copies of all test records be submitted for examination.

The minimum requirements for tensile strength for briquette one (1) inch square in section shall be:

NEAT CEMENT.

24 hours in moist air.....	175 pounds
7 days (one day in air, six in water)	500 pounds
28 days (one day in air, twenty-seven in water).....	600 pounds

ONE PART CEMENT, THREE PARTS SAND.

7 days (one day in air, six in water)	175 pounds
28 days (one day in air, twenty-seven in water).....	275 pounds

Sec. 22. Sand. Fine aggregate shall consist of a mixture of fine and coarse grains of clean, natural sand, screened to pass a one-fourth inch screen, with the coarse grains predominating. Sand shall be composed of hard

silicious particles, free from all decomposed materials, loam or other deleterious matter.

Sec. 23. Aggregate. Coarse aggregate shall consist of crushed stone or washed gravel. It shall pass through a one (1) inch screen and be retained on a one-fourth ($\frac{1}{4}$) inch screen, preferably graded from small to large particles. Crushed stone shall be reasonably free from crusher dust. The particles composing the aggregate shall be clean, hard, durable and free from all decomposed materials, loam or other deleterious matter.

Sec. 24. Proportions for Mixing Reinforced Concrete. Reinforced concrete shall consist of a mixture of one part Portland cement to not more than four (4) parts aggregate fine and coarse either in proportion of one part cement to two parts sand and four parts aggregate, or in such proportion that all voids in the aggregate shall be properly filled.

Mixing shall be done by approved batch mixer, unless the conditions of the work would make hand mixing preferable; hand mixing shall be done only under the approval of the Department of Buildings. Enough water shall be added to the mixture to make it a plastic mass capable of being rammed into all parts of the mould and around all reinforcing members. In all mixing the separate ingredients shall be measured and thoroughly mixed to a uniform color, appearance and consistency before placing. Thirty days after mixing, the concrete shall develop a compressive strength of 2000 pounds per square inch by testing a six-inch cube.

Sec. 25. Bending and Elongation of Steel. The reinforcing steel used in reinforced concrete construction shall conform to the following requirements:

Properties considered.	MEDIUM STEEL.		HIGH CARBON.	
	Plain bars.	Deformed bars.	Plain bars.	Deformed bars.
Ultimate tensile strength in pounds per square inch----	55000 to 70000	55000 to 70000	Not less than 80000	Not less than 80000
Yield point, minimum pounds per sq. in.-----	33000	33000		50000
Minimum per cent elongation in eight inches-----	140000 Tensile strength.	125000 T. S.	120000 T. S.	100000 T. S.
Cold bending tests without fracture.				
Bars under $\frac{3}{4}$ -in. in diameter or thickness.	180 deg. over thickness of bar.	180 deg. over thickness of bar.	180 deg. over 3 times the thickness of the bar.	180 deg. over 4 times the thickness of bar.
Bars $\frac{3}{4}$ -in. in diameter or thickness, and over.	180 deg. over thickness of bar.	180 deg. over 2 thicknesses of bar.	90 deg. over thicknesses of bar.	90 deg. over 4 thicknesses of bar.

The Inspector of Buildings may require certified tests of each size of bar used in the construction, said test to be acceptable for not more than ten tons of material.

The tests for bending may be made on the ground under the supervision of the Inspector of Buildings or his authorized assistant.

Sec. 26. Placing Concrete and Steel. All reinforcement shall be free from paint, loose rust, scale or coating of any character that would tend to destroy the bond. Steel must be accurately located and secured against displacement before concrete is poured around it. All concrete shall be tamped in place within one-half ($\frac{1}{2}$) hour after mixing, and shall be conveyed in place in such a manner that no appreciable separation of the ingredients occurs. Concrete must be worked continuously with suitable tools as it is put in place, and in warm weather must be kept moist for at least seven (7) consecutive days after pouring. Work must be laid out so that partially set concrete will not be subjected to shocks from handling or wheeling materials over it.

Where it is not possible to cast the entire structure in one operation the work shall be stopped; for columns, at the under side of the girders; for girders, at a point midway between supports unless a beam should occur at this point, in which case the joint should be offset a distance equal to twice the width of the beam; for slabs and beams, at the center of the span. Under no circumstances shall a joint be made where high present or future shearing stresses may occur. The plane of all joints shall be made at right angles to the direction of the beam, girder, column or slab. When work is resumed the joints shall be thoroughly cleaned, drenched and slushed with neat cement mortar.

Beams and girders shall not be constructed over freshly placed columns without permitting a period of at least ten (10) hours to

elapse to provide for the shrinkage in the columns.

The longitudinal steel in beams and girders shall be so designed that there is a thickness of concrete between the separate pieces of steel of not less than one and one-half ($1\frac{1}{2}$) times the maximum sectional dimensions of the steel and in no case less than one (1) inch. Some means satisfactory to the Inspector of Buildings shall be used to hold all reinforcing steel in its proper position.

Sec. 27. Centering and Forms. All forms shall be substantially built and secured to prevent movement or deflection during the progress of the work. They shall be tight to prevent leakage of the concrete. An opening shall be left at the bottom of all column forms for removing foreign matter and adjusting the steel, and said openings shall not be closed until just before the concrete is poured. Before placing the concrete, the forms must be thoroughly cleaned of all chips, dirt, old concrete and other foreign matter. Forms shall not be removed until the concrete has set sufficiently to safely resist all stresses to which it may be subjected. Two weeks of good drying weather with a temperature above 60 degrees Fahrenheit shall be taken as the minimum time for the removal of forms where the concrete will support only its own weight. The joists and lagging may be removed in not less than ten days, providing the sheathing under the slabs is properly shored. The time of removal of forms and shores under heavy beams and girders, varies with the design and weather, but in no case shall they be removed in less than three (3) weeks after pouring, providing the beams carry their own weight only. When beams and girders carry construction

loads from above, sufficient shores shall be left in place to carry the loads until the completion of the work. If sufficient shores are provided to support the loads on slabs and girders, the column forms may be removed in not less than four (4) days.

Sec. 28. Placing Concrete in Cold Weather. When concrete is placed in freezing weather, the material must be heated and such provisions made that the concrete can be put in place without freezing.

The use of frozen lumpy sand or aggregate depending on hot water used in mixing to thaw it out, will not be permitted. All reinforced concrete shall be kept at a temperature above freezing for at least forty-eight (48) hours after being put in place. All forms under concrete placed in freezing weather shall remain until all evidences of frost are removed from the concrete and the natural hardening of the concrete has proceeded to the point of safety.

Sec. 29. Inspection. When any reinforced concrete is used in construction, the owner shall provide for the inspection of cement and inerts as required by this ordinance. Unless otherwise authorized in writing by the Inspector of Buildings, the owner shall also provide a special inspector, who shall be on the work continually during the building and removing of forms and the placing of concrete and steel. Said special inspector shall be acceptable to the Inspector of Buildings, and may be required to pass an examination given by said Inspector. He shall make daily reports to the Inspector of Buildings of the progress of the work, on blanks furnished by the department.

Sec. 30. Test for Safety. Within a reason-

able time after erection, and before the building is occupied, a test shall be made of the work as directed by the Inspector of Buildings. For such test the floor panels selected by said Inspector must be loaded to twice the computed live load and must sustain this load for twenty-four (24) hours without undue deflection or other evident signs of failure.

Sec. 31. When to Take Effect. This ordinance shall take effect and be in force from and after the earliest period allowed by law.

DAVID T. LOGAN,
President of Council.

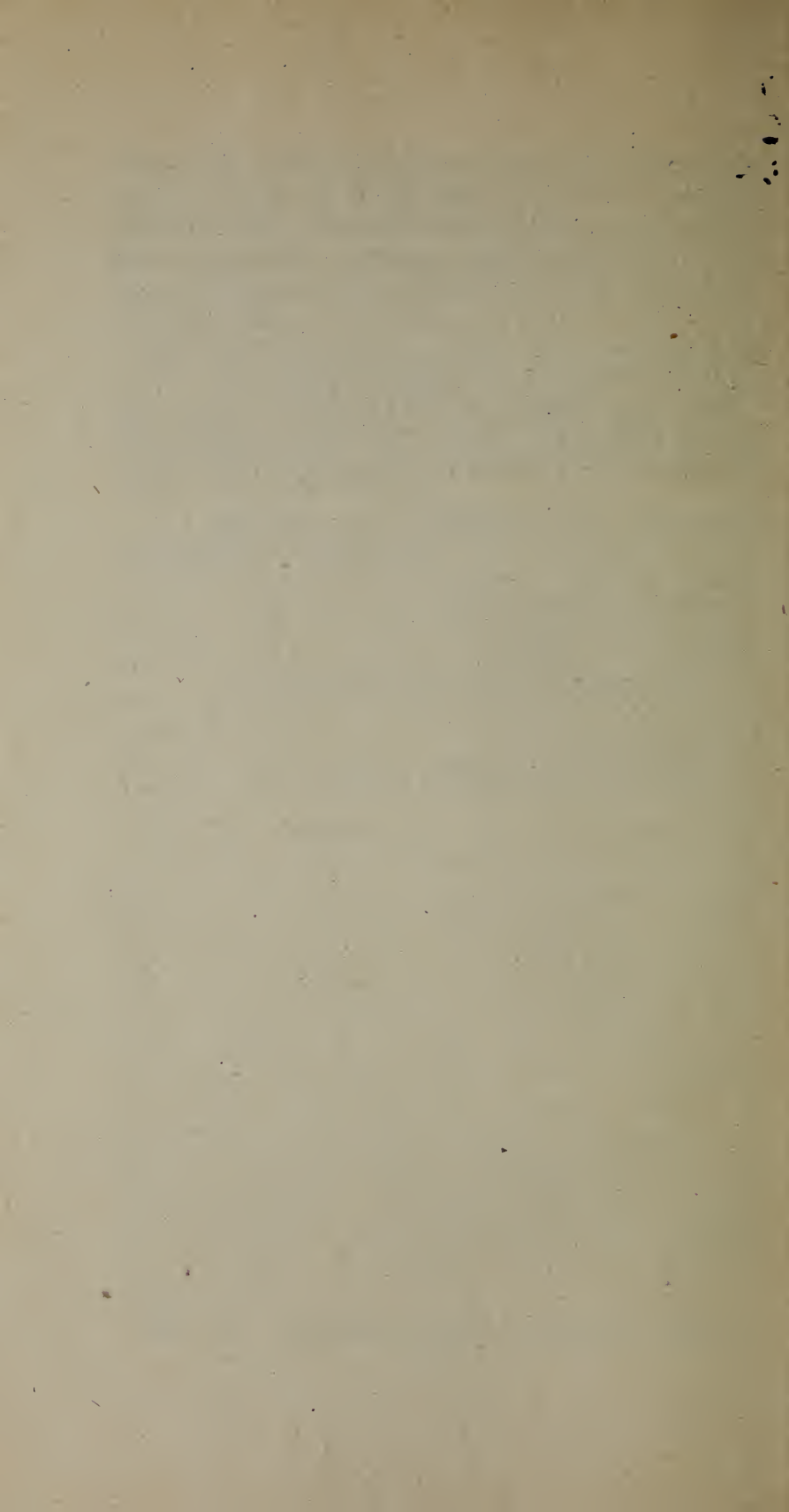
Passed April 7, 1913.

Approved April 7, 1913.

GEORGE J. KARB, Mayor.

Attest:

JOHN T. BARR, Clerk.





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